Weatherwise

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE" — BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

COPYRIGHT 1950, BY AMATEUR WEATHERMEN OF AMERICA

DAVID M. LUDLUM, *Director* — CHARLES A. FEDERER, JR., *Editor*
HANS H. NEUBERGER, *Technical Editor* — D. C. CAMERON, *Research Associate*
ERIC SLOANE, *Art Director*

NACA STUDIES AT BROOKHAVEN

MEASUREMENTS of air turbulence are being made simultaneously at a fixed tower and by an aircraft operating in the same air, for the first time it is believed, at the 420-foot meteorological tower of the Brookhaven National Laboratory at Upton, New York.

The study centers around a light plane from Mitchel Air Force Base which flies in the vicinity of the Brookhaven tower, recording its own movements by means of sensitive instruments. The plane's radio sends impulses which record five-second time marks on photographic film in the plane's accelerometer and air-speed meter at the same time that they are recorded in the tower weather station. This assures complete co-ordination between plane and tower records.

Turbulence and gusts of wind cause bumpiness of the air that places stress on aircraft much as a bumpy road is a jolting threat to some parts of an automobile. Comparison of motions experienced by the Mitchel Field plane with those experienced at the Brookhaven tower in the same air conditions may lead eventually to better methods of describing air bumpiness mathematically and to improved aircraft design.

The flights are being made under various weather conditions for several months. James K. Thompson, project engineer for the National Advisory Committee for Aeronautics, is making the study with the facilities of the Brookhaven meteorological station (see WEATHERWISE, Oct., 1948). First Lieutenant Lloyd L. Wogsland is the pilot of the plane.

The front-cover picture of the meteorology building at Brookhaven was taken by H. Bohnhorst, of the Brookhaven meteorology group, on August 23, 1949, when clouds at several levels were observed. The sky contained scattered cirrus at 20,000 feet; broken altocumulus at 9,000 feet moving from the southwest; scattered stratocumulus at 5,000 feet, also moving from the southwest. The sea-level pressure was 1015.9 millibars, and there was a surface wind from the south-southwest at five miles per hour. The surface temperature was 72.5° F. The visibility was eight miles.

At this time the wind at a height of 410 feet on the tower was southwest at 15 miles per hour, and the temperature there was 71.6° Fahrenheit.

Vol. 3, No. 3 — June, 1950

CONTENTS

NACA Studies at Brookhaven 50
Cloud Photography—Robert E. Cox 51
The Rainmaker's Defense 55
The Birth and Death of a Cumulus
—Joanne Starr Malkus 56
Industrial Forecasting
—William J. Hartnett 60
Reports of the Great Plains Windstorm—May 5-6, 1950 62
Scoutorama Weather Broadcasts 64
Forecasting the Weather—The Relationship of Temperature and Precipitation over the United States to the Circulation Aloft—Donald E. Martin and Harry F. Hawkins, Jr. 65
551.5 69
Workshop for Weathermen
—Charles A. Laird 70

Cover: An interesting sky over the meteorology building at Brookhaven National Laboratory, photographed by H. Bohnhorst, August 23, 1949, at 6:15 p.m. Eastern standard time. (See the article on this page.)

WEATHERWISE is published bimonthly by Amateur Weathermen of America, Franklin Institute, Philadelphia 3, Pa. Membership in the AWA costs $3.00 per year, of which $2.00 is for a subscription to WEATHERWISE and $1.00 for general dues, for members in the United States and possessions and in the armed services. Add 50 cents per annum for postage to Canada and all countries of the Pan-American Postal Union; add $1.00 for all other foreign countries. Make checks and money orders payable to Amateur Weathermen of America. Send notice of change of address three weeks in advance, giving old address. General, circulation, and advertising offices: Franklin Institute, Phila. 3, Pa.

Cirrus clouds photographed by the author on Super XX film at f/18, 1/25-second exposure through a red A filter and polaroid. In the foreground is the Netherlands building at the New York World's Fair, 1939-1940.

Cloud Photography

ROBERT E. COX, CURATOR OF SCIENCE
STAMFORD MUSEUM, STAMFORD, CONNECTICUT

LIGHT! Camera! Filter! Action! Take one; take two! A scene on a large stage in Hollywood, with thousands of dollars in expensive camera equipment and scores of technicians? No, just an amateur weatherman out with his camera making a record of cloud formations that will be used for the future study of clouds in his local weather group or with weatherwise friends.

It has been said, "A photograph is worth a thousand words," and I believe to that should be added, "and can prevent a thousand arguments." How many times after a day of varied cloud formations have two or more weathermen tried to agree in every detail on all the types of clouds they noted? A photograph is a permanent meteorological record, an unbiased representation of conditions in our atmosphere as they existed at a specific moment.

With proper care, even an inexpensive box camera (fixed focus) will take good cloud pictures. The greatest difficulty with this type of equipment is that of getting the proper exposure. A box camera is designed to operate under ideal picture-taking conditions, but with little or no regard to detail in the sky. Most box cameras are in the range f/11 to

Looking up past the Trylon at the New York World's Fair in 1939 toward a fine display of middle-level clouds. Photograph by the author on Super XX, red A filter, f/18 at 1/50 second; enlarged about four times.

f/16 for the lens opening and 1/30 to 1/50 second for the speed of the shutter. In this range detail in terrestrial subjects is rendered printable, but the sky and clouds are generally from two to four times overexposed. This is on the assumption that a film of a speed of 50 Weston (Verichrome or Plenachrome) is used and that the films are processed through the "local drugstore."

Unfortunately, under these conditions one will obtain a negative so dense that it will be necessary to "force" the sky to print by means of extra exposure and at the expense of ground details. The automatic developing done by the processors who return the finished product in a day or two is not bad considering the bulk of orders they have to handle. Films are processed on special racks, many rolls at a time, and the developing time is based on the assumption that every negative is perfect in exposure. The same goes for the printing, also on automatic machines. Much better results can be had by taking your films to the best local photographic store and explaining what you want and paying extra to have a proper job done. Best of all, get a developing kit and process your own films; in the long run you will save money, have fun, and get the results you want quickest.

"How can I get clouds with my box camera?" the beginner often asks. On almost any film and camera an exposure of f/16 at 1/50 second will not render clouds well. The sky registers lighter than it is observed to be because there is a lack of contrast in the sky, considering the color sensitivity of the film. To overcome this, use a filter to darken the sky and increase the contrast. The two most practical are the K-2 and the A filter, obtainable from any camera supply store. If used with a box camera, the K-2 filter will reduce the exposure by 2½ times with Verichrome or Plenachrome film, making the contrast between clouds and sky practically in agreement with the way the eye sees it. The K-2 filter is medium yellow, while the A filter is dark red, but because Verichrome and Plenachrome films are not sensitive to red light the A filter cannot be used with them.

Panchromatic film, such as Panatomic X or Super XX, is sensitive to red light, and used with an A filter will exaggerate cloud and sky contrast. The red filter will cut down the light eight times, so the fastest film should be used. I have generally made my exposures on Super XX film when using a red filter, with most pleasing results. The "slow" box camera should be used this way only on the brightest of days, or underexposure will result. High cirrus clouds make an unusual picture against the very dark sky by this combination of film and filter; although the photograph does not represent what the eye saw, it will sometimes reveal fine detail in these high clouds that escapes the eye because of the lack of contrast.

Unless one processes his own film, he will still seldom be satisfied with the results of

cloud pictures. It is unfortunate that so many believe it is extremely difficult to process films. Many boys and girls in young peoples' camera clubs easily learn the process, which for a single roll of film ought not to require more than 1½ hours total time. It is no longer necessary to run a film in and out of a tray of developer for 30 minutes in total darkness. Today's photographer spends only between two and four minutes in the dark while he loads his film into a lightproof developing tank that has cost him only a few dollars. Thereafter, the actual developing, fixing, and washing are done in a well-lighted room — even at the kitchen sink. Accessories required are chiefly the chemicals, which come prepared, a clock, and a thermometer.

One of the chief advantages of home processing is that a developer giving fine or semi-fine grain can be used. Commercial firms use a rapid, harsh, contrasty developer that gives a dense negative and difficult printing problems. Enlargements cannot be satisfactorily made with negatives of coarse grain. Fine-grain developers yield negatives that are less dense but have good detail in the bright areas and shadows.

Those who own better cameras can use other filter and film combinations. A polaroid filter is more expensive than some of the others, but it adds greatly to the versatility of a camera for cloud and sky photography. A polaroid filter takes sky light vibrating in every plane and absorbs all but light that vibrates in one single plane. The effect is greatest at right angles to the sun and least toward and away from it. This is because at right angles to the sun the light reaching the eye is already polarized. If you have a polaroid filter, view the sky at right angles to the sun and slowly rotate the filter. A darkening of the sky will be noted that is a maximum in a certain position of the filter; continue the rotation and the sky will return to normal. When the position of greatest darkening is reached, most of the already polarized light of this part of the sky is cut off by the filter.

A polaroid filter has no color correction; thus it can be used with other filters to increase the darkening of the sky when a picture is taken at right angles to the sun. Used alone or in conjunction with a yellow or red filter, polaroid gives one several working combinations. With a red A filter polaroid produces an almost black sky, but the exposure factor is increased about 16 times and a fast lens is required.

Infrared also may be used for cloud photography, but this is perhaps best left for ex-

D. C. Wysor, of Ridgewood, New Jersey, took this picture at 7 o'clock in the evening, August 24, 1949, 1/100 second at f/6.3, 3x yellow filter on Super XX film.

Fair weather cumulus over Candlewood Lake in Connecticut, recorded by the author with a combination of red A filter and polaroid. The picture was made at right angles to the sun, the polaroid turned until all the polarized light of the sky was cut out. The exposure was 1/25 second at f/11 on Super XX film.

perienced photographers. With film sensitive to infrared radiation, penetration through haze and nearby thin clouds is remarkable. Infrared pictures, however, give a false impression to the landscape. They really measure the relative heat rather than the light reflected by various objects in the scene.

It is possible to obtain good three-dimensional pictures of cloud levels, especially with middle and low clouds. All that is necessary is to mount two identical cameras on a simple frame so they are parallel and fixed about 18 or 24 inches apart. Point the cameras toward the same part of the sky and snap both shutters at the same time. The same results can be obtained with one camera by moving it quickly between exposures from one end of the frame to the other; the small differences in time between exposures will not be important.

After these stereoscopic pictures are printed, a stereopticon viewer is needed; perhaps you can find an old one around the house. Otherwise, it is easy to make a simple viewer that will permit each eye to see only the picture the other cannot. The camera has effectively increased the baseline between the eyes to 18 or 24 inches and the perspective or three-dimensional aspect of the picture is greatly enhanced. This method can be applied to any camera, but the longer the focal length of the lens the greater the sense of depth that will be obtained.

In color pictures, of course, clouds are important, and perhaps they are easier to photograph with color than with black-and-white film. Color photography itself is not as difficult as most amateurs may be led to believe, but it is more expensive. Filters are usually recommended for color films when photographing scenes under certain conditions. Here again, a polaroid filter is advantageous, for it is one of the few filters that can be used with color film without changing the color balance. But color photography does require a lens faster than f/6.3, and color film is far more sensitive to errors in exposure than is black-and-white.

Returning to the taking of cloud pictures with inexpensive equipment, we repeat that a fixed-focus camera is designed to operate on brilliant days with the subject well illuminated. Substitute Super XX for slower film if the sky is hazy, with cirrostratus or

thin altostratus, but remember to use up all the film on these darker days or later pictures in brilliant sunlight will be overexposed even with a K-2 filter.

If it is very dark, set your shutter mechanism at "T" for time and fasten the camera firmly to a ridged support or a camera tripod. About 1/5 second is right with Weston 50 film and a K-2 filter. A full second is the time required normally to say "one chimpanzee." Make several exposures to allow for differences in timing.

The technique for taking cloud pictures is generally the same for all clouds, whether high or low.

Photography is not difficult and it is lots of fun. Take your camera and start making records of your observed cloud types. From them you will have many hours of pleasure in a new hobby and permanent records for your weather files.

Near sunset, clouds seen in silhouette often furnish excellent subjects for the amateur meteorologist to photograph.

THE RAINMAKER'S DEFENSE

ANY effect of New York City rainmaking operations to date has been felt only in the Catskills, if anywhere, and has had nothing to do with the weather in the city or the immediately surrounding area, Dr. Wallace E. Howell, the city's consultant meteorologist, declared at a press conference on May 17th.

Seconded by Ernest J. Christie, meteorologist in charge of the Weather Bureau office in the city, Dr. Howell reassured New Yorkers that weather in the metropolitan area had developed normally, "without showing meteorological symptoms of anything we are doing."

Dr. Howell obviously was disturbed over the scores of letters, postcards and other messages that have poured into the department from "week-enders in Connecticut and Westchester, and farmers in New Jersey" complaining that city rainmaking had spoiled their activities.

Noting that press reports had said after rainmaking tests that he had been "reticent about claiming credit" for any immediate precipitation, Dr. Howell emphasized that he could not know for a long time what, if any, tangible results he was getting from cloud seeding.

Up to now, he explained, there has not been any exact method of measuring artificial rain. Over several months, rainfall in the target area must be compared with precipitation in immediately surrounding areas before any definite conclusion can be drawn. The minimum time needed for these comparative studies in the present project, he said, would be six months.

Picking up Dr. Howell's remark that "only God can make a cloud," Mr. Christie asserted that meteorologists cannot produce rainfall if the clouds do not exist.

"There have to be conditions favorable for precipitation before we can get anything out of the clouds at all," Mr. Christie said. "The rain and snow which New Yorkers have experienced this spring would have developed anyway.

"The period of bad weather of late April and early May prevailed exclusively along the coast — from Cape Cod, through New Jersey and southward. Just inland, in many cases, there was beautiful weather. It all depends on the way nature shapes up the flow of air. We usually have at least one bad spell along the coast every spring."

New York reservoirs were 85.8 per cent of their total capacity on May 17, 1950, compared with 99.9 per cent one year ago.

May 18, 1950 THE NEW YORK TIMES

At the left, clouds are forming over sandy Cape Cod at midday, their bases at about 2,500 feet, well below the ice-crystal level. Active updrafts and turbulence are indicated by the clouds' hard, rounded edges and tops. The prevailing wind was from rear left to front right of the picture (northwesterly), blowing the clouds directly out over the harbor. The small, thin cloud in the upper part of the center picture is what remains of the middle cloud at the left after 20 minutes of over-ocean travel; at the right it is shown five minutes later. The soft, hazy outlines of the dying cloud indicate that the turbulence and updrafts have disappeared. Engraving, courtesy *Soaring*.

The Birth and Death of a Cumulus

JOANNE STARR MALKUS, ILLINOIS INSTITUTE OF TECHNOLOGY
AND WOODS HOLE OCEANOGRAPHIC INSTITUTION

CUMULUS CLOUDS have often been compared by ground dwellers to airborne cotton puffs; others think of them as tumbleweed blown along by the wind. That these descriptions are too passive will be recognized by anyone who has spent a quiet afternoon flat on his back watching the march of small, white cloudlets across a blue summer sky. No radiosonde, theodolite, or complicated observing instruments are required to discover that such a cloud is not merely a lifeless aggregate of droplets drifting as a coherent body, like a balloon. Rather, it is a transient, dynamic balance between rapid growth and equally rapid destruction. Like a living organism, to maintain its life a cumulus cloud needs a source of energy on which to feed.

It is a common observation, for example, that when an average midsummer cumulus moves out over the cooler ocean, thus leaving its energy source, the heated land, the entire cloud disappears in from five to 30 minutes. The three photographs above show this process occurring in a typical case one summer afternoon on Cape Cod, Massachusetts. Pictures of this sort are best made with a motion picture camera arranged to take lapse-time photographs.* An exposure is made about once every two or three seconds. When these are run off at the normal projection speed of 16 frames per second, the cloud's life processes are greatly accelerated—the clouds boil and bubble along almost like the steam from a railroad engine. For scientific study, such pictures reveal many important features of cloud formation that ordinarily occur too slowly for discovery by naked-eye observation.

At the Woods Hole Oceanographic Institution, the camera used for cloud studies was

*The writer will be glad to furnish on request details of the construction of such a shutter-triggering mechanism for an ordinary movie camera.

a Cine-Kodak 16-millimeter with an electrical shutter-triggering mechanism to expose the film once every two seconds. A red filter of type A was used with Plus X panchromatic film. The resulting pictures, when projected, showed cloud motions and internal changes speeded up 32 times.

One of the most valuable revelations first suggested by these movies was that, in general, the speed of cumulus clouds does not correspond exactly with the speed of the wind. Cloud fragments seen streaming out in one direction only have shown that often the clouds are moving *through the air* and not just drifting with it. Experimental verifications of these motions have been made by means of radar photographs of clouds taken by the Thunderstorm Project of the United States Weather Bureau. It is possible theoretically to predict that the cloud-air relative motions must occur frequently, based on the principle that the wind does not remain constant with height above the ground, but increases or decreases in speed and often changes its direction.

The velocity of a cloud can be dealt with in two parts, the vertical component and the horizontal. In clouds the vertical forces and therefore the changes in vertical velocities are extremely complicated. Happily, the horizontal forces are small and much more easily dealt with, since they are due to friction alone.

First let us consider a thermal chimney in which air ascends with no friction at all through an environment in which the wind velocity is different from that at the base of the thermal. The air in this chimney will retain its original horizontal velocity (in accordance with Newton's first law of motion), and hence in the upper levels will have a horizontal speed and direction different from that of the air around it. Incidentally, the presence or absence of liquid water in the form of cloud is unimportant in the foregoing considerations—the thermal may exist with or without forming cloud.

Frictional forces, however, come into play between the thermal or cumulus cloud and its environment. This is not the same as the simple air resistance that slows down an automobile at high speed, for in the case of ordinary cumulus clouds and thermals that type of "friction" is found to be very small. (For clouds the size of thunderstorm cells, on the other hand, it would probably be much larger).

The frictional force of importance for ordinary cumulus is that caused by the entrainment of environment air into the ascending chimney. Measurements show that after a cloud or thermal has risen about 4,000 feet the amount of air moving upward has commonly doubled or tripled, the excess flowing in from the surroundings, mixing with the rising air, and being dragged along. But this entrained air comes from outside the thermal and hence possesses the horizontal velocity of the higher levels. When it mixes with the thermal or cloud air it imparts some of the outside horizontal velocity (momentum or energy, strictly speaking) to the cloud air, thus bringing the horizontal motion of the cloud air closer to that of the higher levels.

Nevertheless, the speed difference between a cloud and its surrounding air remains five or six miles per hour or more at heights of

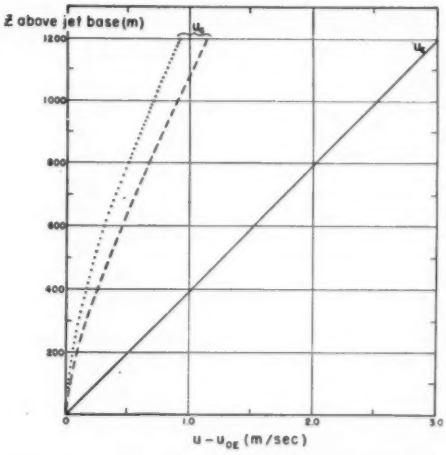


Fig. 1. A graph of horizontal cloud velocity versus height. The external wind is given by the solid line, increasing by three meters a second in 1,200 meters (6.7 miles per hour in about 4,000 feet). The horizontal cloud velocity for normal rates of mass entrainment is given by the dotted curve, and for double this rate of entrainment by the dashed curve. Thus, altering the rate of entrainment affects the relative motion of cloud and wind only slightly. The velocities plotted are those in excess of the velocity at the jet base. Engraving, courtesy *Soaring*.

5,000 feet above cloud or thermal base. The difference in speed is proportionately less at lower elevations. A typical example is shown in Fig. 1, where the external wind increases with height, a situation most often the case in the lower atmosphere. Under these conditions, clouds will move downwind more slowly than the air. When the wind speed decreases with height, on the other hand, the clouds will actually move downwind faster than the wind itself, because of their origin at lower levels where the wind is stronger.

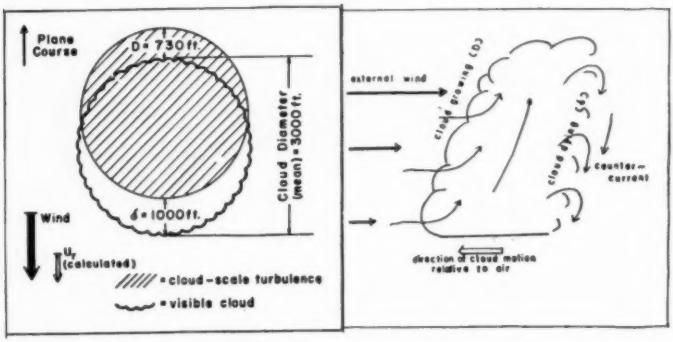


Fig. 2 (left). The asymmetry between visible cloud and turbulence. Cloud-scale turbulence denotes the large values of turbulence usually associated with cumulus.

Fig. 3 (right). The predicted cross section of moving cumulus with external wind shear. The "detrained" or dying portion of the liquid cloud is caught in the descending countercurrent.

Were a cumulus cloud not moving horizontally with respect to surrounding air, but merely drifting with the wind, the inflow of entrained air could be symmetrical around the periphery of the cloud. If, however, the ascending jet moves along through the air with a speed greater than the inflow speed, the addition of velocities shows that on one side the inflow will be increased, while on the opposite edge actual outflow of air from the jet must take place. On the outflow side, then, liquid cloud particles are pushed away from their updraft energy source just as surely as if those cloud particles moved out over the cool of the ocean. That part of the cloud, therefore, can be expected to die.

Once again look at the three Cape Cod photographs and note that dying clouds are not turbulent, while young and growing clouds are highly so. Therefore, a difference in location between the turbulent region and the region of visible cloud is to be expected, as shown schematically in Fig. 2. The region D, of turbulence and no visible cloud, is the side of maximum entrainment, where new cloud can be expected to form. The region δ, of visible cloud and little or no turbulence, shows where the cloud is dying. The small double-line arrow represents the relative wind felt by an observer riding in the cloud.

These predicted asymmetries of a cloud and its turbulence were first verified by airplane traverses of tropical cumuli made by a group of meteorologists from the Woods Hole Oceanographic Institution. The numbers in Fig. 2 represent an average of eight such observations. In all these cases, as is normal in the region of the trade winds, the problem was simplified by the fact that the wind increased but did not change its direction with height. The clouds moved directly downwind more slowly than the wind itself. The asymmetry was as predicted, and the data show it to be of the correct magnitude if it is assumed that 25 minutes are required for the detrained fragments to dissipate. In view of the rather high relative humidity (70 per cent) in the tropics, this conclusion seems quite reasonable. On the single occasion where the wind decreased with elevation, the asymmetry was found to be reversed, although the observing plane continued to head into the wind.

During the summer of 1949 many airplane flights through cumulus clouds in the Woods Hole area showed that the same types of asymmetries occur in middle-latitude clouds as in the tropical cumuli. In our latitudes, however, the turning of the wind with elevation, rather than a simple increase or decrease in speed, is often the predominant variation. The clouds in general maintain a motion more nearly characteristic of the wind at a considerably lower level. This fact had an

interesting practical consequence, for the investigating airplane had to fly crosswind to chase the clouds during the Woods Hole observations; this was at first a cause of considerable consternation to the pilot.

Practically speaking, then, the common method of estimating upper-level winds from watching cloud motions must be used with caution, since clouds possessing strong updrafts indicate neither the wind direction nor the speed at the elevation where they are observed. An extreme example is provided by the familiar orographic cloud that forms and maintains itself close to a mountain peak for several hours despite a strong horizontal wind. It has been the purpose of this article to show that the ordinary, active summer cumulus may maintain similarly a motion relative to the wind by constantly growing on one edge and dissipating on the other.

Fig. 3 sets forth the vertical mechanism of a cumulus in a fairly strong wind which increases in speed with elevation, as indicated by the heavy arrows. Note that the cloud is "losing" to the wind, and its relative motion is therefore to the left, as indicated by the arrow below the cloud outline. An asymmetry in vertical motion is predicted as well as the asymmetry in turbulence. The balancing downward current is shown in this case confined mainly to the leeward region of the cloud, while the most intense updrafts are in the central and windward portions. This distribution of motions accounts for the rolling over or slow somersaulting so often associated with moving cumulus clouds; this is clearly revealed by lapse-time motion pictures.

The fact that updrafts are nearly always stronger on one side of a cumulus than on the other has frequently been noted by glider pilots, and is also revealed by the thundercloud data of the Weather Bureau Thunderstorm Project. The downdraft that is so important in a mature thunderstorm — because it brings down the rain and typical gust of cold air — must have a tendency to develop on that side of the growing cumulus where the updrafts are initially weakest. That this preferred location can be related to the wind shear has been indicated already, and is further demonstrated by work now going on at Woods Hole. The study of summer cumulus over Cape Cod and the adjacent islands is being continued, and will be reported on at a later occasion.

The study of the small summer cumulus is not just an interesting pastime. Every thunderstorm once began its life as such a small cloudlet, and careful study of the structure and growth of this initial and simpler stage can be expected to contribute important information about the far more complex mature stage of the mighty thunderstorm factory of squall, hail, and lightning.

Meteorologists are also coming to recognize the important role of the continuous formation and decay of cumulus clouds over the tropical oceans in supplying energy (largely in the form of latent heat in water vapor) for ultimate use by the large-scale wind systems of the atmosphere. For example, consider the cumulus clouds formed over one square kilometer area 50 per cent covered by clouds, one third of which are actively rising at any given time. These can easily provide a *net* upward transport of energy equivalent to that released by a 1,000-pound bomb of TNT going off every second.

Ed. Note: The foregoing article is based in part upon an article, "Cumulus, Thermals and Wind," by the same author, in the September-October, 1949, issue of *Soaring*, the journal of the Soaring Society of America, Inc.

ANTI-LIGHTNING SEEDING

At a recent scientific conference on thunderstorm electricity held at the University of Chicago, E. J. Workman, president of the New Mexico School of Mines, and S. E. Reynolds, project supervisor, told of experiments they had made which indicate that a seeding process, like that used to produce rain, may lessen the amount of electricity generated in clouds.

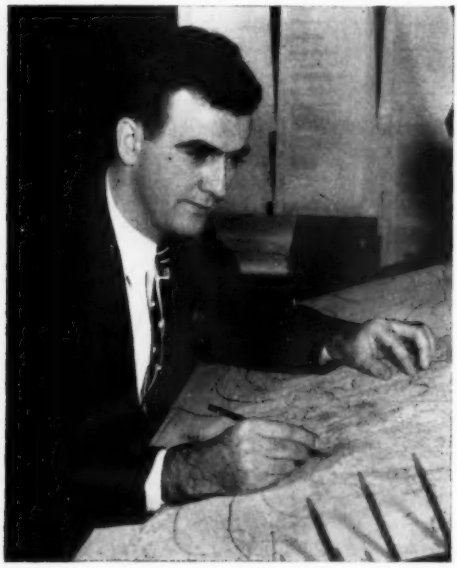
In thunderstorms moisture is carried into the upper level of the storm, where it freezes. And when water freezes, electricity is generated. In laboratory experiments chemicals were dropped into freezing water, and the New Mexico investigators were able to decrease the amount of electricity generated in the freezing process. Chemicals were also introduced into actual clouds during heavy rains on three occasions. In each instance the electrical generating powers of the thunderclouds were lessened.

INDUSTRIAL FORECASTING

WILLIAM J. HARTNETT. PRESIDENT. WEATHERCASTS OF AMERICA

BEHIND the oft-told story of precision bombing in the recent war was a less known factor that made the decisive strikes possible — precision weather forecasting. In those days, weather engineering was spurred by military needs, but the postwar implications of wartime developments in meteorology were clear both to the men at plotting maps and to industrial engineers at home. A new type of precision forecasting service has now been established by private meteorological consultants who help their clients work with the weather instead of against it.

These weathermen to industry take up their specialty where the familiar general public forecast leaves off. Many of them have become specialists who serve the needs of only a few types of industries, as in the case of my own organization, Weathercasts of America. Ours is one of a dozen private meteorological firms now engaged in industrial forecasting. Located in St. Louis, Missouri, we have concentrated on serving gas and electric utilities and the construction industry. The work is geared to the daily production and distribution problems of those particular companies.



The author looks over a weather chart. Photograph by Peter Ferman.

There is a marked difference between the general forecast, upon which we all depend when we dress in the morning or plan an evening's entertainment, and the pinpoint forecast required by industry, although the preliminary work for both types of forecast is identical. Plotting and analyzing surface and upper-air charts is the same, but the final form of the forecast for gas and electric utilities must give details of cloudiness and precipitation, icing conditions, maximum and minimum temperatures, and wind velocities. Construction companies also need detailed precipitation forecasts, together with sufficient warning of cold waves with subfreezing temperatures.

Degree of cloudiness is an important factor for an electric light company, for the effect of the weather upon housewives' activities is felt strongly at generating stations. On a dreary overcast day, thousands of homes are lighted longer in the morning and earlier in the afternoon, washing and ironing schedules are changed, and the peak load period demand for electricity is far above the normal for a sunny day. The utility company uses precision forecasts to keep its power loads on an even keel by knowing when to generate additional power to meet extra demand.

Even more dramatic is advance weather knowledge that protects lines and equipment in storm periods. A severe ice storm can destroy power transmission lines overnight and throw thousands of homes into darkness, cold, and confusion, for when the electric power goes off automatic furnaces, refrigerators, deep-freeze units, and many pumps are useless. When icing is expected the company load dispatcher keeps a close watch over the danger sections; he short-circuits sections of the lines to melt off the ice before the accumulation becomes heavy enough to be destructive.

For gas utilities, accurate temperature forecasts are as important as are degree of sunlight forecasts for the electric utilities. Without accurate foreknowledge of a severe cold outbreak, a company furnishing natural gas

A beautiful disaster — in Ohio in 1940. Forecasts of icing weather can minimize the damage caused by ice storms. Photograph, courtesy Southwestern Bell Telephone Company.

would find itself supplementing its average load supplies with costlier manufactured gas and, if this is not sufficient, imposing a priority system on its customers.

Natural gas companies keep a close watch on the range of temperatures to be expected along a pipeline from its source through intermediate distribution points and on to the terminus. The company seeks to operate at the most efficient pressure to supply all of its outlets without overtaxing the line with too high pressures. Yet it must be prepared to handle the demands of sharp temperature drops at any point on the line.

This means warning forecasts a few days in advance, and more precise temperature forecasts as the danger hour approaches. Without such warnings, costs can mount to six figures for the pipeline and its industrial users, for in a gas shortage the industrial users are cut off first. This can shut down hundreds of gas-burning industrial ovens and furnaces, halt production and put thousands of people out of work until the cold snap eases. Accurate, in-time forecasts avert such emergencies for the pipeline companies, the local gas distributors, and their customers.

In the construction industry, knowledge of the weather permits a building foreman to cancel crews the night before, or to cancel outside workers and order in additional crews of inside workmen for a day too rainy or cold or windy for the originally scheduled work. Union requirements that "show-up" wages be paid to crews that report but cannot work put an extra premium on accurate weather predictions in this high-cost field.

Brickwork, cement pouring, and plastering are seriously affected by cold temperatures. Contractors can use heaters to protect newly poured concrete in below-freezing weather. Grading and excavation operations can be deferred to dry days if wet weather is forecast. If machinery rented for one operator for a particular day cannot be used because of weather, an accurate forecast makes it possible to send the machinery elsewhere instead of having it stand idle.

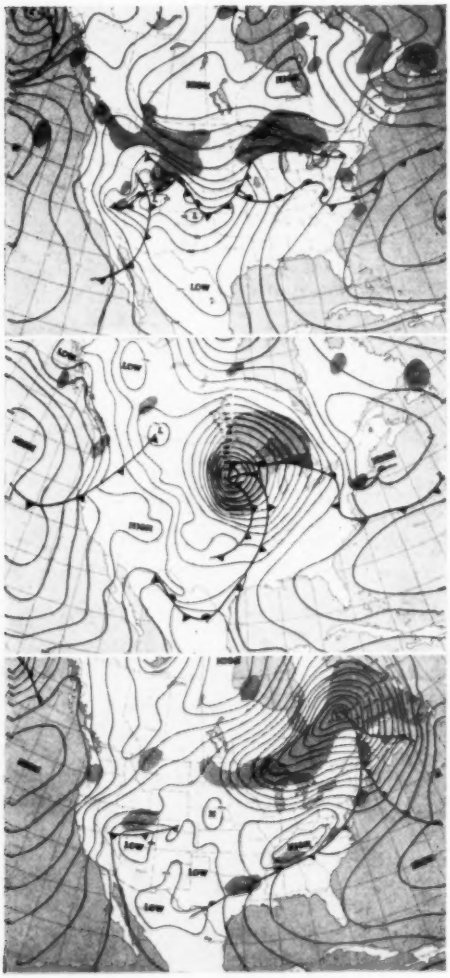
Weather surveys are extremely valuable in the location of new industrial plants. In 1949, a gas and electric company in the Middle West wrote us for information about an anemometer that would indicate accurate wind direction and velocity, and an instrument was recommended. The company engineers, it developed, wanted to know when the wind was blowing from the east-northeast, east, or east-southeast because they had noted that a substation located west of a generating plant (on the west side of the Mississippi River) was experiencing severe electrical

(Continued on page 68)

Reports of the Great Plains Windstorm — May 5-6, 1950

From Minnesota:

For the third time in less than a year the state of Minnesota has experienced severe windstorms of hurricane force with near-record low barometric pressure. The most recent storm of May 5-6, which was centered over central Kansas about midnight of the 4th, moved northward and at 12:30 p.m. of the 5th was centered east of Watertown, South Dakota. As the storm crossed into the southwestern portion of Minnesota it increased in intensity and in the next six hours moved north-northeastward toward Bemidji, where it was centered at 6:30 p.m. of the 5th. It then moved eastward to be centered north of Duluth at 12:30 a.m. on the 6th of May.



From top to bottom, these surface charts are for 1:30 p.m. on May 4, 5, and 6, 1950. The pressure in the May 5th low was down to 975 millibars. From May 5th to 6th the low moved about 1,400 miles to the Quebec-Labrador area, and polar air swept from the Dakotas to the Atlantic Coast. USWB charts.

At Minneapolis the lowest barometer (sea level) was 28.80 inches at 5:29 p.m. of the 5th. This is the second lowest sea-level pressure of record for Minneapolis, the lowest being 28.78 inches on March 15, 1920. The highest wind during the passage of the storm over Minnesota occurred at Duluth, where peak gusts of 88 miles per hour were recorded.

Property damage was widespread but mostly minor except it was heavy in an area extending from Kanabec County in east-central Minnesota northeastward to Lake Superior. Ten persons were injured in the Duluth-Superior area, and a property loss estimated at a million dollars was suffered. Heavy rains contributed much to the damage, and some streams overflowed their banks. However, there was no damage to growing crops because of the unusual lateness of the season.

M. R. HOVDE
Section Director, USWB
Minneapolis, Minn.

From Iowa:

The lowest barometer reading at Des Moines occurred at 11:00 a.m. May 5th with 29.01 inches or 982.4 millibars. This reading exceeds the previous low for May, which was 29.09 inches back in 1918. The strongest wind here was an instantaneous gust at 1:00 p.m. from the south-southwest at 90 miles per hour. From our triple register data at the city office, the fastest mile was 71 miles per hour from the southwest at 12:15 p.m., while the maximum five-minute velocity was 60 miles per hour, beginning at 12:15 p.m. and also from the southwest. The fastest mile reading was the second high of record for this station.

Although there was some thunderstorm activity early during the strong wind period, only a trace of rain fell at Des Moines. In Sac County, in northwestern Iowa, at the town of Nemaha, newspaper accounts stated that hailstones as large as 10½ inches in circumference fell for a short period during the preceding evening.

In Des Moines there were more than 4,500 homes without electric service during portions of the day. In residential areas shingle and roof damage was widespread, with occasional glass breakage. The latter was more common in the downtown areas where there are more large windowpanes. Two of Des Moines' radio stations were off the air during the after-

noon because of a power failure. Over the state three persons were killed while out in the windstorm.

Newspaper accounts now state that insurance companies are reporting loss claims the largest ever filed with their respective companies in their history. Much greater damage would have been sustained, however, if this storm had occurred later in the year during the crop growing season. The storm of last October 10th, although it did not produce such record readings, probably caused overall damage greater than this May storm because it considerably reduced the Iowa corn crop.

C. E. LAMOUREUX
Section Director, USWB
Des Moines, Iowa

From Wisconsin:

This storm was similar to but a little more severe than the one of last October 10th, and preliminary reports indicate more damage than from the earlier storm. Southwesterly gales prevailed on the 5th and part of the 6th. The highest velocities occurred during the afternoon of the 5th in most parts of the state, with speeds up to 60 miles per hour; gusts at Milwaukee reached 90, Green Bay 101, La Crosse 89, and Madison 84 miles per hour.

The lowest barometer reading at Milwaukee was 29.25 inches (sea level) at 3:28 p.m. Central standard time. Temperatures were in the 70's over much of the state, the warmest of the season. Heavy thundershowers occurred in the northwestern section, causing flash floods and soil erosion, but precipitation was very light and scattered in other parts of the state.

Probably every community in Wisconsin suffered some storm damage, although much of it was minor, such as broken windows, shingles blown from roofs, frame garages and other small buildings demolished, and trees uprooted. Utility companies reported poles and wires down in many places. Boathouses and docks were damaged on many inland lakes. In the Milwaukee area two high television towers and a roller coaster were blown down. At Superior, two large ore dock rigs, a railroad roundhouse, and a large warehouse were wrecked. The storm caused the death of three people. Monetary loss from the storm is unknown but may exceed two million dollars.

H. J. THOMPSON
Section Director, USWB
Milwaukee, Wis.

RED RIVER FLOOD

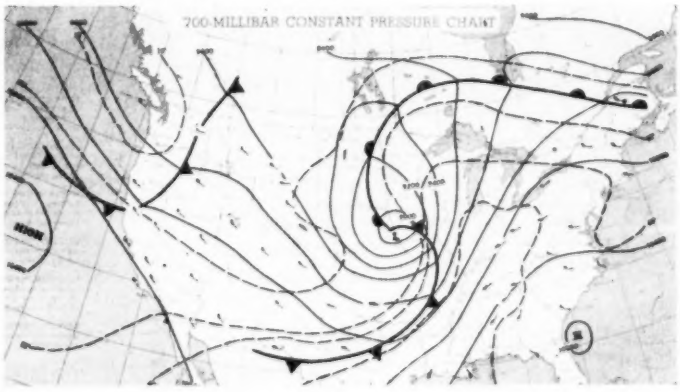
An April combination of three meteorological conditions sent the Red River, which flows northward between North Dakota and Minnesota and through Manitoba, into the highest stages ever reached during the past century. The city of Winnipeg received the full brunt of the flood waters in the middle of May, causing the evacuation of 100,000 persons, with 17 per cent of the city under water.

This spring was one of the coldest on record in the area. Heavy snows, up to 30 inches, were combined with a quick breakup of the ice late in April. The onset of spring temperatures at the same time that moderate rains fell caused ice jams to yield and loose walls of water in the tributaries of the Red River. Temperatures in the minus 40's had frozen the land several feet deep. Early in May many low-lying fields were already flooded. The windstorm of May 5-6 churned the flood waters into huge waves that completed the demolition of many buildings.

At Winnipeg, the Red River had risen to 30.2 feet at 8:00 a.m. May 17th; this was 12.2 feet above flood stage. The Red River, usually 1,000 yards across in Winnipeg, was three miles wide in southern parts of the city. Damage in the business districts was estimated between 50 and 250 million dollars, and crop damage was set at 15 million.

CORRECTION

The dates in the note on page 31 of the April, 1950, issue of **Weatherwise** should have read January and not March, referring to the "Arizona Freeze."



The upper-air chart at 700-mb constant pressure level at 10:00 a.m., May 5th. A closed low, indicative of a well-developed storm, is centered on the Nebraska-Iowa border. The continuous lines show height in feet above sea level. The dashed temperature lines are at 10° intervals and at 32° Fahrenheit. USWB charts.

Frank Romaine, WNJR weatherman, and boy scouts broadcast from the weather booth at the Eagle Rock Scoutorama. Photograph by Almon W. Johnston.

SCOUTORAMA WEATHER BROADCASTS

WEATHER played an important part in the recent Scoutorama of Eagle Rock Council, Boy Scouts of America, in which more than 2,000 scouts took part in the gymnasium of the high school at Montclair, New Jersey. A feature of the three-day show was the weather booth of Montclair Troop 7, from which two 25-minute broadcasts, dealing mostly with weather, were aired over radio station WNJR of Newark.

Conducting the broadcasts was weatherman Frank Romaine, whose five-minute weather broadcasts have been an early-morning fixture on WNJR for more than two years. A number of scouts who had built homemade weather instruments for display in the booth were interviewed; each was given a brief weather quiz and the winner was awarded a novel type of plastic rain gage.

In addition to the homemade instruments, a complete display of weather apparatus was shown by Science Associates. The rear wall of the booth was decorated with copies of WEATHERWISE, arranged to spell the letters WNJR.

Although the Scoutorama included 42 other booths of scouting skills and activities, the weather booth drew the largest crowds. During the broadcasts, the throngs around the booth stopped all traffic. The booth was sponsored by John Blondel and Son, Montclair fuel dealers sponsoring Mr. Romaine's regular radio broadcasts.

TRANSATLANTIC WEATHER BALLOON

A 20-foot plastic balloon has made a high-speed trip by air across the United States and the Atlantic Ocean to land 7,000 miles away in Norway.

The balloon flight, one of many conducted by New York University's constant-level balloon project, was launched on March 2nd at Holloman Air Force Base, New Mexico. It landed at Myrdal, Norway, on March 4th, where it was found on top of a seven-foot snowdrift by a railroad worker.

Balloons of this type are under development that will carry meteorological instruments and will be able to make constant soundings at a fixed level. In this way, many blank spots on the weather map over ocean areas will be covered at frequent intervals.

FORECASTING THE WEATHER

The Relationship of Temperature and Precipitation over the United States to the Circulation Aloft

DONALD E. MARTIN AND HARRY F. HAWKINS, JR.
EXTENDED FORECAST SECTION, UNITED STATES WEATHER BUREAU

TEMPERATURE PATTERNS IN THE UNITED STATES DURING SUMMER

IN PREVIOUS articles it was shown that there are certain key areas for determining, from the circulation aloft, surface temperatures in the United States during winter. One might wonder whether these same areas are equally significant for the summer season. To answer this question, let us compare the various elements which are associated with extreme surface temperatures in the summer season with similar factors for winter.

For example, in the entire area of the United States east of the Rocky Mountains cold wintertime weather is usually associated with outbreaks of continental polar air masses originating in Canada and traveling southward over the United States, while warm weather is generally produced by maritime air masses from the Gulf of Mexico or the Pacific. The contrasts of temperatures at the source regions of these air masses are very pronounced in winter, and advection into the United States can result in abnormal temperatures more or less irrespective of local influences. In the summer season, however, there is much less temperature contrast at the different air mass sources. Inasmuch as the upper-level circulation becomes more sluggish in summer, it is not surprising that surface temperatures in the United States are found to be associated more closely with local circulation characteristics than with the circulation over remote areas.

The same technique employed in winter has been used in locating key areas for relating circulation patterns to summer surface temperatures. This involves construction of typical warm and cold circulation patterns, found by averaging 700-mb height values at various intersections of latitude and longitude for several cases of extreme warm or cold surface temperature at a given city. The contrasting cold and warm patterns emphasize those features of the circulation which predominate in the extreme cases. As explained previously, these features are brought out more clearly through the use of height anomaly charts. This so-called composite map technique is illustrated by selecting Denver, Evansville, and Boston as cities representative of areas influenced by different geographic and topographic effects. The composite charts of 700-mb patterns and departures from normal are reproduced in Figs. 1, 2, and 3.

The composite charts for these cities are similar in certain respects. For cold surface temperatures each has a center of below normal heights near the station, and for warm temperatures a contrasting center of above normal heights in approximately the same location. The height anomaly becomes more significant in summer since it reflects the local circulation over the station, including such features as the

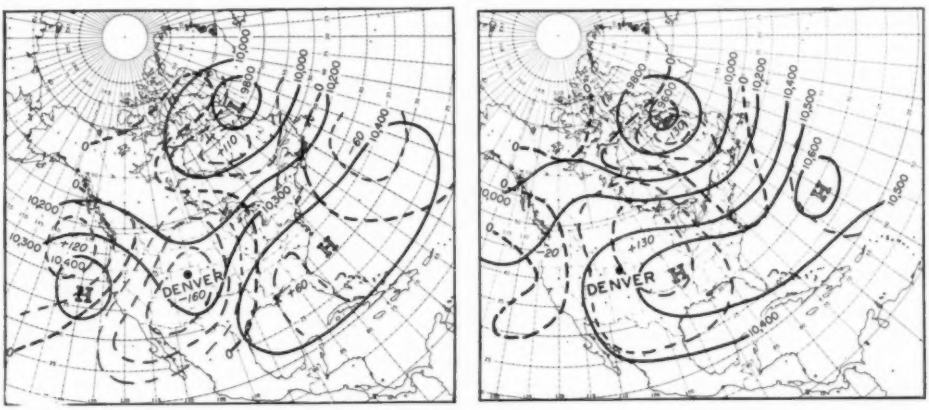


Fig. 1a (left) and 1b (right). Composite 700-mb charts and height anomalies for cold and warm surface temperatures, respectively, at Denver, Colorado.

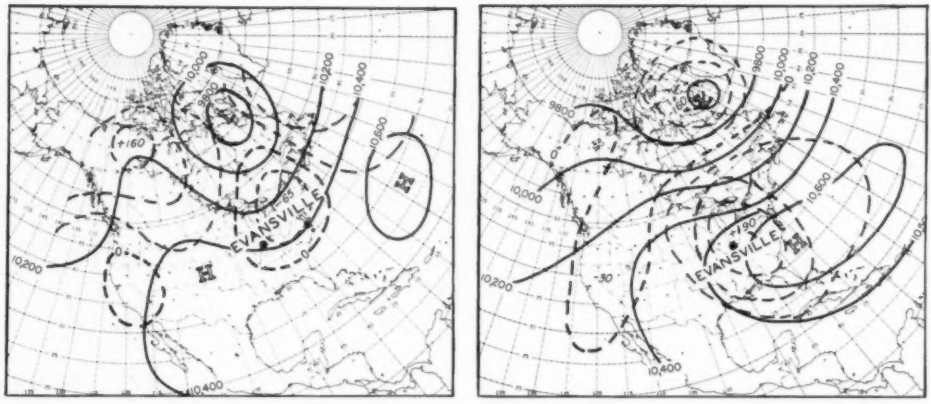


Fig. 2a (left) and 2b (right). Composite 700-mb charts and height anomalies for cold and warm surface temperatures, respectively, at Evansville, Indiana.

curvature of the upper-level contour lines, stability of the air mass, and the proximity of mean troughs and ridges. In turn, these determine the amount of cloudiness, rainfall, and solar insolation permitted to modify the original air mass characteristics. Compared to winter, on the other hand, the key area far removed from the station becomes less significant in summer because of the diminished importance of air mass transport as the determining factor.

At Denver cold surface temperatures in summer (Fig. 1a) are associated with northwesterly upper-level winds which blow from a high pressure ridge off the West Coast into a trough of low pressure near the station. These winds carry relatively cold maritime air from the northern Pacific and, together with a low height of the 700-mb surface over the station, appear to be of fundamental importance in giving Denver cold surface temperatures. For warm surface temperature (Fig. 1b) the trajectory of the air is reversed and an abnormally strong pressure ridge is located over the station. The winds come from the warm continent to the southwest, which becomes a source region for hot continental tropical air in summer. These contrasting features of the warm and cold circulation patterns are portrayed more strikingly by the lines of equal 700-mb height anomaly. In these charts, below normal heights are found near the station for cold temperatures (Fig. 1a) and above normal heights for warm temperatures (Fig. 1b).

Another but less important set of contrasting centers of height anomaly is found off the West Coast of the United States near 40° north, 130° west. This is apparently another key area, and whether or not height anomalies there oppose or agree in sign with those near Denver determines the magnitude of the surface temperature anomaly at Denver. When these two factors are operating to produce a strong northeasterly deviation of the wind direction from normal (as illustrated by the lines of equal height anomaly in Fig. 1a) abnormal cold results, while warm conditions are found when the height anomalies in these same areas operate to give strong southerly wind components relative to normal. The height anomalies in these two key areas therefore serve as a basis for the objective measurement of those features of atmospheric circulation which are important in relating the surface temperatures to the upper-level patterns.

It is interesting to note that in the transition from winter to summer the key point near the station remains unchanged in position but increases in importance relative to the one farther away. In the case of Denver this latter center shifts southward from 60° north, 130° west to 40° north, 130° west, as a result of the change in the primary cold air source region from Canada in winter to the northern Pacific in summer.

Evansville is representative of a continental type of climate. The contour patterns for the summer composite charts are similar to those for winter. Cold temperatures (Fig. 2a) are associated with a strong ridge in the Northwest and a trough near the station, with a resulting southward transport of relatively cool, dry Canadian air, while warm patterns (Fig. 2b) show a ridge near the station and strong west winds to the north, conditions which prevent the influx of cold polar air masses and allow domination by warmer tropical air. Once again these features are demonstrated more forcefully by the patterns of height anomaly where in the cold case (Fig. 2a) a center of below normal heights is found near or slightly east of the station, while for the warm pattern (Fig. 2b) a center of positive height anomalies is found in approximately the same area.

Other less sharply contrasting areas are found in central Canada, where positive height anom-

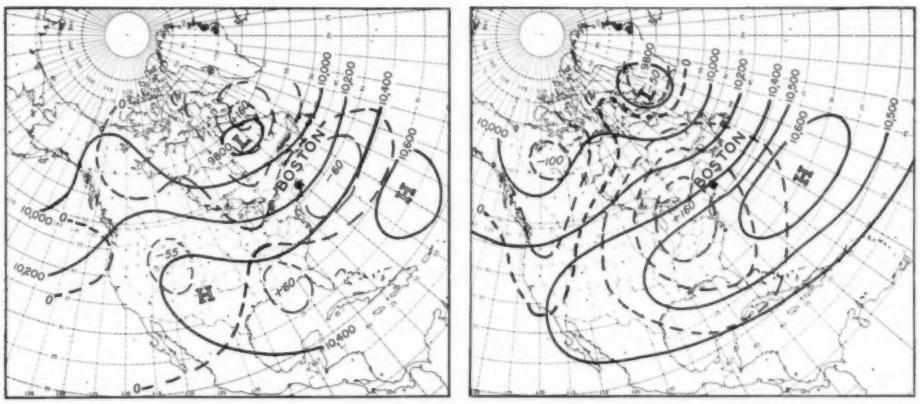


Fig. 3a (left) and 3b (right). Composite 700-mb charts and height anomalies for cold and warm surface temperatures, respectively, at Boston, Massachusetts.

alies are found for the cold pattern (Fig. 2a) and below normal heights on the warm pattern (Fig. 2b). These anomaly centers, acting in conjunction with those near Evansville, produce northeasterly air flow relative to normal for the cold pattern and southerly flow for the warm pattern. The point in Canada where the 700-mb height anomaly is most important for determining the temperature at Evansville changes from 60° north, 130° west in winter to 60° north, 100° west in summer, as the cold air source region shifts from northwest Canada to Hudson Bay. Even at Evansville, however, the center near the station increases in significance relative to the center in Canada in summer.

At stations like Boston the Atlantic Ocean exerts an important influence on temperature, especially during the summer. The composite charts show that below normal temperatures at Boston (Fig. 3a) are associated with cyclonically curved contours, southward displacement of the subpolar low, and a weakening of the normally strong Bermuda high. Above normal temperatures accompany anticyclonically curved contours, a northward displacement of the polar low, and northwestward extension of the Bermuda high.

These factors are again emphasized on the charts of height anomaly. Above normal heights to the north and below normal near Boston (Fig. 3a) indicate a decrease in the normal westerly circulation, thereby permitting more frequent influxes of cool maritime air from the Atlantic. On the other hand, above normal heights near Boston and below normal to the north (Fig. 3b) imply a warmer continental climate. A comparison of the key points for relating 700-mb height anomalies to the surface temperatures at Boston in winter and summer shows that the points near the station remain in approximately the same position in both seasons, but the one in Canada shifts from 60° north, 120° west in winter to around 60° north, 60° west in summer. This shift emphasizes the change in the primary cold air source region from northwest Canada to the Atlantic.

The foregoing three articles have presented a method of relating the upper-level circulation pattern to the surface temperature for both winter and summer. This approach has also been used for spring and fall. Similar techniques are being used to relate rainfall to the upper-level circulation. These will form the basis for the next three articles in this series, to be written by Harry F. Hawkins, Jr. This article was written by Donald E. Martin.

SEA-SALT RAINMAKERS

According to Science Service, newly discovered rainmakers are tiny unseen bits of sea salt floating high in the air even where the ocean is far away. Electron microscope photographs of tiny atmospheric particles around which raindrops form were shown to the American Geophysical Union in Washington, D.C., recently by C. L. Hosler, meteorologist at Pennsylvania State College. Some of these particles are only a millionth of a centimeter in diameter.

The work at Penn State has shown there are many more types of such atmospheric nuclei than had previously been thought. In addition to the tiny crystals of salt, blown hundreds of miles inland from evaporating ocean spray, magnesium chloride particles and silica dusts so fine they cannot be seen by ordinary microscopes have been identified. The electron microscope has also shown that the shape of the individual particle has a great deal to do with whether or not a raindrop will form around it.

Science Service notes that a German scientist during World War II was studying condensation particles.

WINDIKATOR

wind direction
wind velocity—
at a glance!

Here's a chance for every amateur weatherman to add to the accuracy of his hobby! WINDIKATOR — a *precision-built*, pocket-size anemometer — gives exact wind direction, wind velocity at a glance! Non-magnetic, rust and corrosion resistant, WINDIKATOR is guaranteed accurate. $8.75. Leather belt carrying case $1.50. Model A indicates velocity 5-30 MPH, Model B, 10-60. If your dealer can't supply you, write . . .

The WINDIKATOR COMPANY
120-W Tremont St. Boston 8, Mass.
Export Division: 15 Moore St., New York 4, N.Y.
Cable Address: "Minthorne"

Keep Up With the Weather

Read *Weatherwatch*

A daily chronology of weather events in the United States — includes maps and charts of monthly temperature and precipitation. Here are six pages full of exciting weather news.

WEATHERWATCH is sent as a privilege of membership to all members of the AWA. Individual subscription is $1.25 for 12 monthly issues

Send today for a free sample copy.

AMATEUR WEATHERMEN OF AMERICA

The Franklin Institute, Philadelphia 3, Pa.

INDUSTRIAL FORECASTING

(Continued from page 61)

flashovers when the wind blew from these directions.

A preliminary investigation and a later meteorological survey revealed that the flashovers occurred with fog or fog and drizzle accompanying the easterly winds which blew stack gases and fly ash from the parent generating station over to the smaller substation. The sulfur dioxide in the stack gases ionized the water droplets of the fog and drizzle, and this, in turn, produced the flashovers. The entire power plant output would arc through the ionized air across the insulators, completely knocking out the substation.

After this survey had identified the saturated air as the meteorological factor in the problem, a forecasting program was inaugurated to warn the engineers when conditions of easterly winds with fog and drizzle could be expected. In this vicinity, this type of weather occurs with warm frontal activity near the city. A survey just completed showed that the flashover problem would be minimized if the substation were moved 400 feet from its present location.

The initial warning, the revised forecasts that achieve high accuracy as the deadline approaches, and the forecast that tells when an emergency alert can be lifted are all a part of the 24-hours-a-day service given by a private meteorological firm. Industries have learned that, because the cost of its operation is spread over a number of clients, the private firm can bring weather engineering within the cost range of many companies that could not justify the maintenance of a staff of trained meteorologists on their own payrolls.

Precision weather forecasting is a war-born activity now grown to professional stature.

Weather Exchange

Classified advertisements for this column are 8 cents a word, including address; minimum ad 20 words. Remittance must accompany orders. Write Weatherwise, AWA, The Franklin Institute, Phila. 3, Pa.

FOR SALE: Secondhand Taylor sling psychrometer. Good condition. For details and price write Ervin K. Overlund, Route 2, Box 67, Silverton, Oregon.

FOR SALE: German-made barograph; 7-day chart in millimeters; charts 12" x 3⅝"; Swiss mechanism. Write: Eggeling, c/o 1504 E. Hampton St., Tucson, Arizona.

551.5

CLIMATOLOGY

W. G. Kendrew. Oxford University Press, London, 1949. 383 pages. $7.50.

THIS is a third and revised edition of a work first published in 1930 under the title of **Climate**. Since much of the material has been rewritten and new material added, it was felt that a change in title was justified. Mr. Kendrew is a reader in climatology, University of Oxford, England.

The organization of the present work differs from most texts on the subject in that the treatment is not by continents but rather by areas that exhibit a similar climate type. Thus, the material on mountain and plateau climates finds discussions of the Alps, Himalayas, and the Rockies in a connected narrative. The main emphasis by Kendrew, thus, is on the natural environment that has shaped the evolution of man, animals, and plants.

The work is organized into six parts: Insolation and Temperature, Atmospheric Pressure and Winds, The Vapour of the Atmosphere and Its Condensation, Mountain and Plateau Climate, The Weather of the Westerlies, and Some Climatic Types.

The main portion of the material, naturally deals with the British Isles and the Continent. The treatment of the climate of Switzerland is full, and was most fascinating to the reviewer. The great winter contrast between valley and upland locations in regard to insolation, temperature, and cloudiness is discussed and the meteorological and physiological reasons behind the high reputation as health resorts of the Swiss mountains are presented.

The weather fan will find the book chock-full of weather facts and data that have been collected in Mr. Kendrew's studies. Numerous maps and charts accompany the text, and the synoptic situation behind many climate types receives adequate treatment. Air masses of Europe, especially, are mentioned, and the discussions proceed generally in consonance with the air mass and frontal analysis of weather situations.

One small slip was noted. The lowest temperature ever officially recorded in the United States was −66° F., one degree lower than the figure stated in the book.

When will a work of similar scope appear with the main emphasis on the United States? Not since the publication of Ward's **The Climates of the United States** in 1925 has a full-scale treatment of our national climate appeared. Certainly such an effort would receive an enthusiastic reception from all concerned with the weather.

D. M. L.

PRACTICAL ANSWERS TO HYDROLOGIC PROBLEMS

- in flood control work
- irrigation
- drainage, etc.

Here's your guide to today's practical uses of hydrologic theory, data and technique . . . a clear explanation of the development and application of practical methods for computing and forecasting streamflow, evaporation, snowmelt, etc. The book covers these techniques and problems characteristic of hydrology in the United States. It examines data on basic and complex phenomena of the hydrologic cycle . . . shows how to use the various hydrologic tools in the solution of problems . . . and gives information of importance in highway and airport drainage, small water-supply projects, etc.

APPLIED HYDROLOGY

By Ray K. Linsley, Max A. Kohler and Joseph L. H. Paulhus, all of the United States Weather Bureau

689 pages, 6x9, fully illustrated
$8.50

This book covers all important phases of hydrology — from atmospheric temperature, measurement of precipitation and evaporation formulas to the runoff cycle, streamflow routing machines, and the design of dams and reservoirs. It discusses hydrograph analysis, waves, design criteria, design and operation of water-control works, river forecasting, etc. Quick reference appendices provide methods for graphical correlation of two, three, four or more variables and give sources of hydrologic data, physical constants, conversion tables and equivalents.

SPECIAL FEATURES

- **Presents techniques for correlating hydrologic data**
- **Describes use of multiple graphical correlation in development of rainfall-runoff and streamflow-routing relations**
- **Analyzes unit hydrograph, snowmelt, storm analysis**

SEE THIS BOOK 10 DAYS FREE

McGRAW-HILL BOOK CO., INC.
330 W. 42nd St., N. Y. 18, N. Y.

Send me Linsley, Kohler and Paulhus' APPLIED HYDROLOGY for 10 days' examination on approval. In 10 days I will remit $8.50, plus few cents for delivery, or return book postpaid. (We pay for delivery if you remit with this coupon: same return privilege.)

Name .....
Address .....
City ..... Zone .... State .....
Company .....
Position WW-6-50

This offer applies to U.S. only.

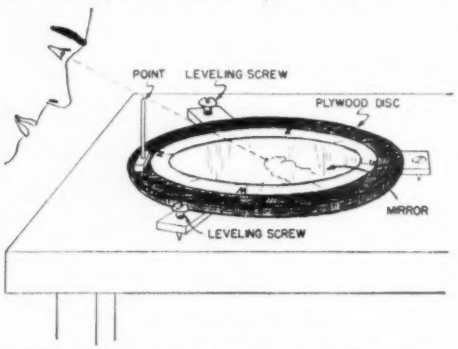
WORKSHOP FOR WEATHERMEN

CONDUCTED BY CHARLES A. LAIRD

How to Construct A Nephoscope

A NEPHOSCOPE is used to determine the speed and direction of clouds. Generally, it consists of an elevated grid through which clouds are observed, or a flat mirror in which the speed and direction of clouds are determined by watching cloud reflections. The nephoscope described here is of the latter type, and is probably the most commonly used.

A 6" round mirror is used. Obtain a glass disk (ordinary window glass will do) and paint it black on one side. A black mirror of this type is excellent for observing clouds. The base of the nephoscope consists of a disk of ¾" plywood, 10" in diameter. Projecting from this base are three short lengths of wood, extending out about 1" and fastened to the plywood disk with small nails or screws. These three sections of wood are arranged equal distances apart around the disk. Extending through these wood sections are three wood leveling screws. Their size is not critical. Drill small "starting holes" in the wood sections before turning in the screws, so as not to split the wood.



The mirror is glued to the top side of the plywood disk and situated in its center. Be sure you glue it on with the paint side down. Put a small dot of white paint in the exact center of the mirror. To determine cloud direction (described more fully later), glue a circle of paper around the mirror and flat on the plywood surface. This circle should have an outside diameter of 7½". The circle may be graduated in degrees (0 to 360) or marked in the eight directions, N, NW, W, and so forth.

A small sighting point is necessary, consisting of a piece of ¼" dowel glued in a hole in a small block of wood. The height of this sighting point is critical and must be contained in the formula for determining cloud speed as described later. You will want several lengths, but you might start with a sighting point with its tip 3" above the bottom surface of the mirror — above the top surface of the plywood.

Set the nephoscope on a table or any form of pedestal mounting you may wish to construct; place a small spirit level on the mirror surface and adjust two of the leveling screws until the mirror is level. The nephoscope should be oriented in such a manner that the south direction on the paper scale actually points north.

To determine cloud direction, place the sighting point in a position around the mirror so that a cloud image appears at the dot in the center of the mirror. Watch the movement of the image, keeping it in line with the sighting point. The direction of motion of the cloud can be determined by observing the point on the graduated scale where the image passes off the mirror. With the nephoscope oriented in the manner described, the direction from which the cloud is moving will correspond with the scale graduation toward which the image moves.

The determination of cloud speed is somewhat more difficult and depends for its accuracy on a knowledge of cloud height above the ground. You should use a stop watch to determine the time of travel of the cloud image from the center of the mirror to its edge. Sight the cloud image in the manner shown above, starting the watch the instant you have the image located at the center of the mirror and stopping it when the image reaches the edge. The formula for cloud speed is:

$$\text{Speed} = \frac{\text{cloud height} \times \text{mirror radius}}{\text{height of pointer} \times \text{time}}.$$

(If you care to derive this formula, note that it wouldn't hold true if the sighting point were mounted a considerable distance horizontally from the mirror.)

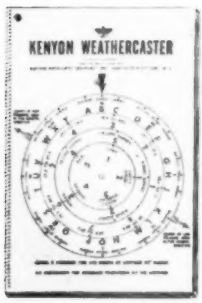
In the instrument shown here, the sighting point height is the same as the mirror radius, so these terms cancel out and the formula becomes:

$$\text{Speed} = \frac{\text{cloud height}}{\text{time}}.$$

If you use cloud height in feet and time in seconds, the answer, of course, is in feet per second; you may want to convert this to miles per hour.

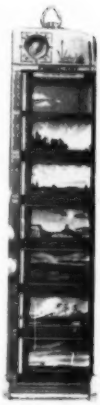
Determination of cloud height is not always easy, although observers become very adept at judging this distance by eye observation. Ceiling balloons, ceiling lights, and the newer automatic ceilometers are valuable aids in determining cloud elevation. If you live near an airport, you may obtain cloud and ceiling heights from pilots or Weather Bureau offices.

Forecasting Aids



901 WEATHERCASTER — This handy booklet translates current weather conditions into a weather forecast. Four plastic dials are adjusted by the observer to match current conditions. The four elements are: sky condition, barometric tendency, height of the barometer, and wind direction. A key number then enables one to read the appropriate forecast from inner page tables. Size: 6½ x 9 inches. **$5.00**

901



902 WEATHER GUIDE — The basic concept of the Weather Guide is that the major factors determining short period weather changes are revealed by the cloud formations in the sky and the wind direction on the ground. One merely selects the cloud picture most nearly matching current conditions, sets the wind arrow opposite the cloud picture, and reads off the forecast. The Weather Guide comes in seven models for use in each of seven zones of the United States. Size: 8 x 2 x 1 inches. **$12.50**

902

306-8

306 METEOROLOGICAL BAROMETER—U.S. Weather Bureau type. Contains best-quality movement. Special aneroid cell is temperature compensated. Open-face silver dial has double scale with graduations to 0.02 inch and to one millibar. Adjustable pointer for comparative readings. Overall diameter, 5¼ inches; thickness 2½ inches. Weight 1 lb. 11 oz. For use between sea level and 3,000 feet. **$30.00**

307 METEOROLOGICAL BAROMETER for medium altitudes. Same as #306 but for use between 2,900 and 7,100 feet. **$35.00**

308 METEOROLOGICAL BAROMETER for high altitudes. Same as #306 but for use between 5,950 and 11,300 feet. **$35.00**

"Everything for the study and practice of meteorology."

Science Associates

401 North Broad Street **Philadelphia 8, Pa.**

FOR PRECISE READINGS ON RELATIVE HUMIDITY and TEMPERATURE ...RELY ON BENDIX FRIEZ

Accurate information on humidity and temperature is essential in laboratory and scientific work. Be sure of these facts with Bendix-Friez precision instruments built to the most exacting standards by the foremost manufacturers of weather instrumentation.

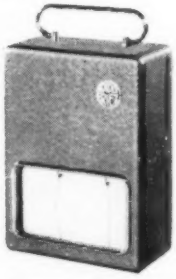
BENDIX-FRIEZ

Hygrodial

Model 185

Precision Humidity and Temperature Indicator

Hair-operated and calibrated to professional standards of accuracy by the maker of the world's finest weather instruments. Handsome, modern case—4" high, 5½" wide, 1⅞" deep.



BENDIX-FRIEZ

Model 160

Portable Humidity and Temperature Recorder

3" x 5" charts, 10 or 30 hour records. Modern design . . . handy for small space and difficult locations . . . built to meet unusual conditions.

BENDIX-FRIEZ

Model HA/2

Hand Aspirated Psychrometer

Accurate readings obtainable without special skill. Psychrometric readings can be taken at any point desired however inaccessible.

WRITE:

FRIEZ INSTRUMENT DIVISION of

1358 Taylor Avenue

Baltimore 4, Maryland

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N.Y.

Bendix AVIATION CORPORATION